Clean Scan Implementation

Implementation Guide: Clean Scan

The Pure Photonics products provide a very low frequency noise, making them suitable for sensing applications. In that low-noise mode, the Pure Photonics firmware adds frequency flexibility, so that the laser can be scanned over a certain rage in single-mode operation and with very low noise. In addition, the laser can be quickly moved from one frequency to another.

Combining these two features, we have a mechanism to scan over the full tuning range of the laser, covering every frequency by making relatively short single-mode scans (typically 100GHz) followed by quick jumps to the next frequency. This is fully implemented in our **Clean Scan** firmware.

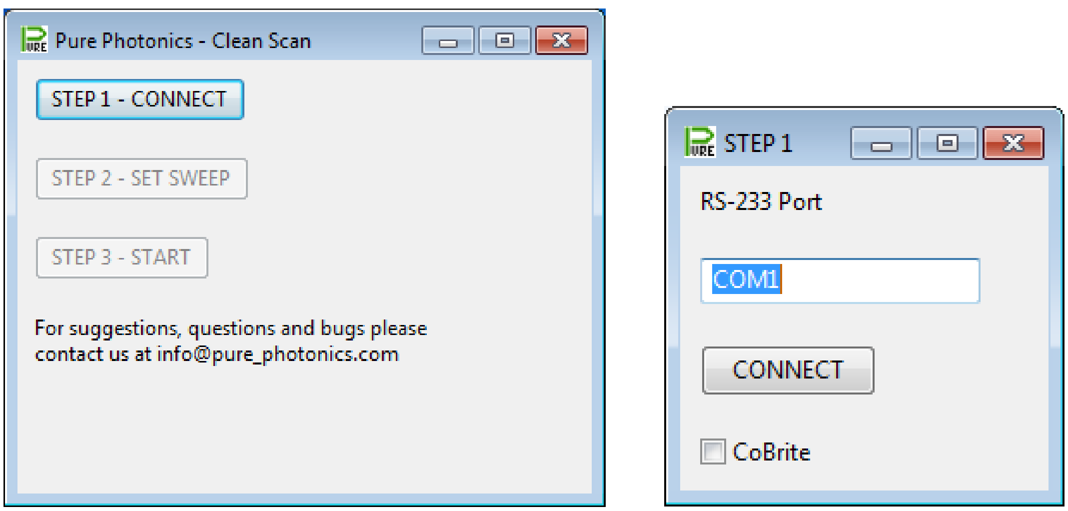
This implementation guide describes how to operate the Clean Scan, both in the Graphical User Interface and at the RS-232 interface level.

1. Graphical User Interface

The Graphical User Interface (GUI) is a convenient means to experiment with the Clean Scan interface and to do initial experiments. We do anticipate that for real-life applications, most user will want to have more functionality and would opt for implementation in their own custom application. If you are not comfortable with programming your own application, please contact Pure Photonics for assistance.

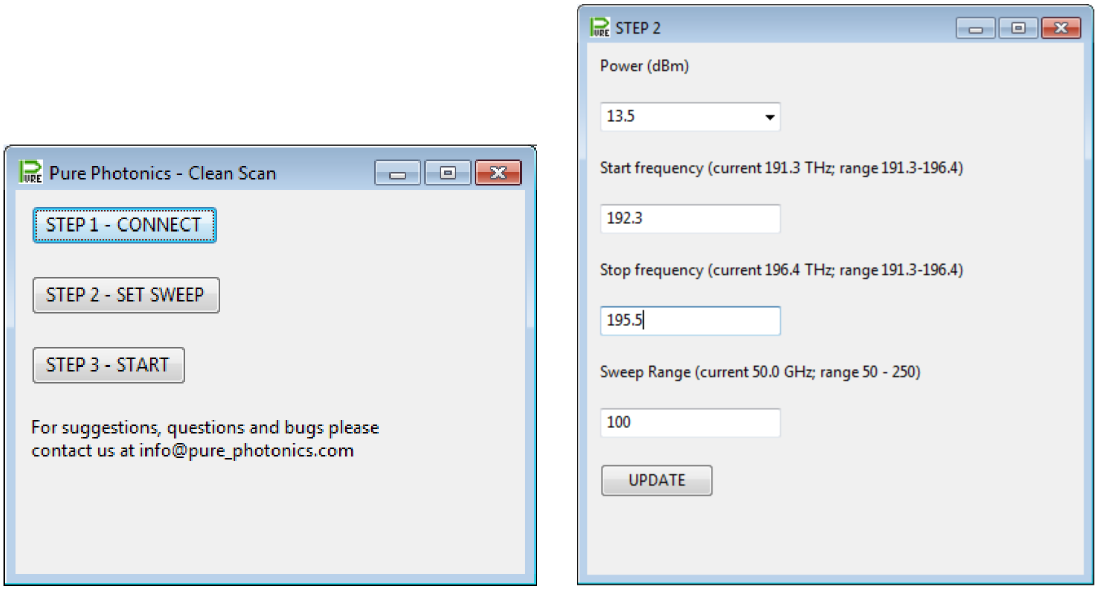
The GUI can be downloaded from the Pure Photonics website (http://www.pure-photonics.com/downloads1/) and will contain an executable file (‘PP GUI.exe’) and several ‘.bat’ files. Activate the Clean Scan GUI by double-clicking ‘PP GUI Clean Scan.bat’.

A screen will show with ‘STEP1’, ‘STEP2’ and ‘STEP3’ buttons. Only ‘STEP1’ is selectable. Press this button and indicate the COM port where the laser is located (e.g. COM1). If you are using a CoBrite product, select the ‘CoBrite’ selection box. Note that the program works best with COM-port IDs below 10. If the COM port ID is higher, then please use the Windows Hardware Manager to adjust the COM port ID.



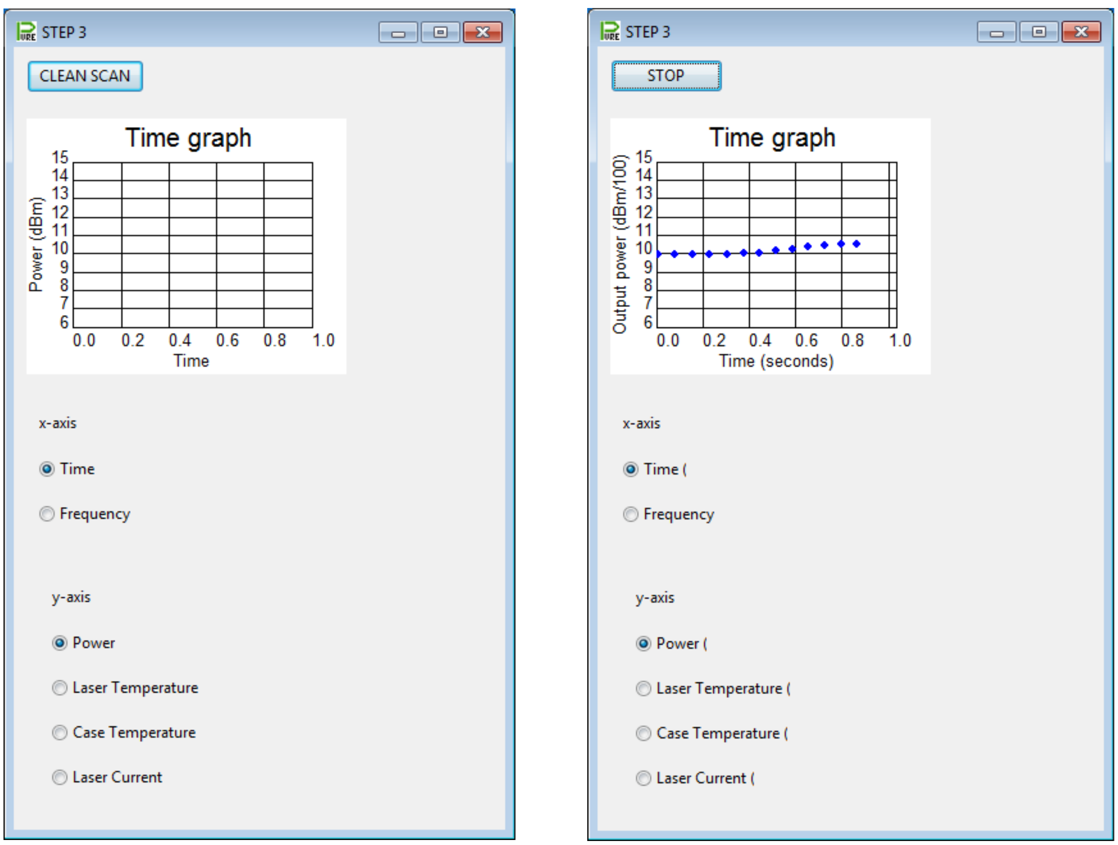
Opening screen of Clean Scan GUI (left). ‘STEP1-Connect’ screen (right)

After the contact with the laser is established, the ‘STEP2’ and ‘STEP3’ button will become available. Press ‘STEP2’ and select the starting frequency and stopping frequency. Also select the sweep-range (we recommend 100 GHz for optimal speed and coverage) and the sweep speed (we recommend 20GHz/sec). The program will automatically add 20% to the range (10% on either side) to ensure overlap between different sweeps. Select ‘Update’ to save the settings.



Main screen after connection to laser (left) and 'STEP 2' screen

Now select 'STEP3' and press 'Clean Scan'. This will enable the laser and then start the scan and the progress can be followed on the graph and the parameter display below. The scan can be aborted by pressing the 'Clean Scan' button again.



'Step 3' screen at the start and during Clean Sweep

To operate the laser in Clean Scan mode several files are pre-requisite.

1. The '.current2' file is obtained from Pure Photonics and contains calibration parameters. This file need to be stored in the //logfiles directory.
2. The '.li', '.sled' and '.map' files can be obtained from Pure Photonics or be generated in the calibration GUI. Essentially every .map file provides the required operating set-points for a specific power level. These files need to be stored in the //logfiles directory. This is also where the logfile from the Clean Scan can be found.
3. The firmware needs to contain the Clean Scan code. All 8.2.x firmwares are suitable for Clean Scan

2. RS-232 interface

The RS-232 interface follows the conventions, as outlined in the OIF-MSA (http://www.oiforum.com/wp-content/uploads/OIF-ITLA-MSA-01.3.pdf). Several registers have been added to enable the Clean Scan functionality.

On the next page the flow-chart for the Clean Scan function is given. It requires firmware versions 8.2.x and assumes that the user has the calibration files '.current2', '.li', '.sled' and '.map'. These files can be used as-is or in some way embedded within the user application.

The basic flow is to turn-on the laser, start the Clean Scan and while the laser is executing one sweep around a center-point, feed the setpoint for the center-point of the next sweep. The laser can then jump to that next point after completion of the sweep. The standard sequence of jumps is sequential (in one direction), but there is no requirement to make the step logical and, in-fact, any sequence can be followed. Due to the thermal nature of the sweep, a sweep towards higher frequency (lower temperature) is followed by a sweep to lower frequency (higher temperature).

It is recommended to calculate all center-points with the same sled temperature. In that way the temperature ranges of the different sweeps are well matched and it minimizes the jumping time between sweeps. However, this is not a requirement.

It is recommended to use a 100GHz sweep range as this optimizes the speed of the sweep (because the sweeps get slower at larger deviations and because more jumps are required with shorter sweeps).

It is recommended to apply a slightly larger sweep range than the spacing between center-points, to allow some overlap at the edges (e.g. 120GHz sweep range for 100Ghz spacing). The simplest implementation is to make this symmetric, with overlap at both sides. With some optimization, this range may be even made asymmetric, to allow the laser more overlap at the beginning of the sweep to stabilize (in principle, the last part of the sweep is more stable than the begin of the sweep).

Flow Chart

	Step	Register	Value	Comment
	Create table of set-points (frequency, sled temperature, current)			To be obtained from measurement or calculation
	Activate the laser			Turn on power supplies
	Set sled base temperature	0xF0	32000	Choose a value approx. 2 degrees above the target temperature (i.e. 24.5C for 22.5C target)
	Change sled base temperature	0xE5	1	Register 0xE5 starts the Clean Scan if Clean Mode = 1; otherwise locks the based sled temperature
	Set current adjust value for 1st point	0xE7	TBD	From the pre-defined table for the first set-point
	Set laser to starting frequency	0x35	e.g. 190	THz part
		0x36	e.g. 9000	10*GHz part (in this case 190.9THz)
	Set Scan range	0xE4	100	To set the scan range to 100GHz; It is recommended to set the scan range > scan interval to create some overlap
	Set power level	0x31	1300	To set to 13dBm
	Set Channel to 1	0x30	1	To make sure that the laser comes on at FCF (as set in 0x35 and 0x36)
	Turn laser on	0x32	8	SENA bit 3 = 1
	Monitor NOP until laser is locked	0x00		Pending flags in bit 9-16
	Turn on Low-noise mode	0x90	1	Activate the Clean Mode
	Wait 0.5 seconds (recommendation)			
	Turn on the Clean Scan	0xE5	1	Turn the Clean Scan on. Laser will start increasing the frequency
	Set next sled temperature (C *1000)	0xF0	29.973	To set to 29.973C (value*0.001)
	Set next filter 1 temperature	0xF1	e.g. 12123	To set to 62.123C (50C + value*0.001)
	Set next filter 2 temperature	0xF2	e.g. 31875	To set to 81.875 (50C + value*0.001)
	Set current adjust value	0xE7	TBD	From the pre-defined table for the first set-point
	Set central current	0xF3	1343	To set the current in the center of the scan (e.g. at 22.5C) to 134.3mA)
	Read Clean Scan state	0xE5	READ	
No	if Clean Scan state & 0x0001 == 0			
Yes	**Next setpoint ?**			
	No			
	Stop Clean Scan	0xE5	0	
	Exit Low-noise mode	0x90	0	
	Disable laser	0x32	0	

The parameters for the Clean Scan are obtained from the different calibration files. These calculations can be performed real-time or can be pre-calculated for a specific frequency trajectory (depends a bit on the system where it is going to be implemented).

For each setpoint the following 5 values are needed: filter1 temperature, filter2 temperature, sled temperature, drive current, current adjust value. They can be obtained as described below. To double check the calculations, we recommend to use the GUI. The logfile will contain a list of calculated setpoints.

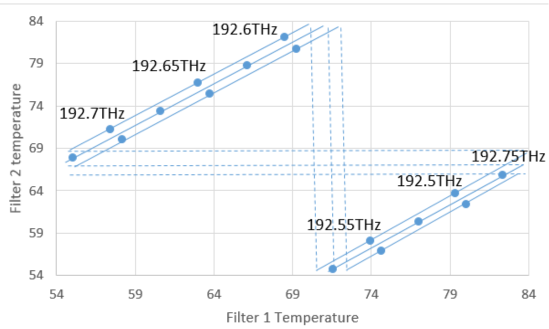
Filter1 and Filter2

The '.map' files contain the set-points for filter1 and filter2 at a specific grid (typically 50GHz grid). The setpoints at a specific frequency can be obtained by interpolation. However, one needs to be careful for discontinuities.

Say the target frequency is f_{target}. Then two grid points can be selected grid1 with the closest lower frequency and grid2 with the closest higher frequency. If the filter temperatures for the grid2 point are both lower than the filter temperatures for the grid1 point, then there is no discontinuity and a simple interpolation can be used.

If this condition is not met, a discontinuity is present. In that case, it is recommended to extrapolate to the f_{target} with the two next grid points with lower frequency and the two next grid points with higher frequency (make sure for both extrapolations that there is no discontinuity between those two points). Select the calculated setpoint with filter temperatures closest to 69 degrees C.

In the below graph the filter1 and filter2 setpoints of the grid are shown for a specific laser. The dots are the points in the '.map' file. The solid line indicates the continuous frequency and the dotted lines show how those lines are connected (no valid setpoints on the dotted lines). The line can be followed starting at frequency 192.5THz. Between 192.55THz and 192.6THz there is a discontinuity. And again between 192.7THz and 192.75THz.



In this example, e.g. frequency 192.53 can be calculated with normal interpolation. Frequency 192.56 needs to be extrapolated from set points 192.5 and 192.55THz. Frequency 192.595 needs to be extrapolated from set points 192.6 and 192.65THz.

Sled temperature

The sled temperature needs to be extrapolated from the closest grid frequency setpoint, that was used in the calculation of the filter1/filter2 setpoints (i.e. referring back to the example in the previous section, for 192.53 use 192.55; for 192.56 use 192.55 and for 192.595 use 192.6. The sled temperature is calculated with the 'sledslope' in C/GHz (typically about -0.23 C/GHz). This value is either obtained from Pure Photonics for the specific unit, or can be read from register 0xE8 in units of 0.0001 C/GHz.

The allowed sled temperatures for a specific frequency set point are spaced 3C apart. It may be that the one that was calculated is not the most appropriate for the Clean Scan. To correct it the temperature needs to be changed in steps of about 3C to be similar to the previous sweep. The mode-spacing can be obtained from the '.sled' file.

The '.sled' file contains clusters of valid sled temperature values (for a specific frequency), spaced by approximately 3 degrees C. The values in the '.sled' file should be used to calculate an accurate mode distance. The easiest way is to assign integer values to the clusters and then do a linear fit. Alternatively, you can take the average of each cluster and then simply take the average of the distance between clusters.

With the example of 23.23C and a mode spacing of 2.97 C, the value 23.23 + 2*2.97 = 29.16 is the closest mode to 30C.

Drive current and current adjust value

The '.current2' file contains the drive current and the current adjust value as function of power and frequency. A simple interpolation at the right power level will produce the right values.

Adjustment to one common center point temperature

To optimize speed and efficiency of the switch between sweeps, it is recommended to make the sled temperature of the center point the same between sweeps. After calculation of the center-point based on the desired grid, it can be offset by a specific temperature, as long as the filter1 and filter2 values are also changed.

For example, if the calculated sled temperature is 29.16C and the target is 30C, the sled temperature is raised 0.84C and the frequency is lowered by (0.84 divided by a sledslope of e.g. 0.23C/GHz) 3.65GHz.

Now, the filter1 and filter2 set points also need to be adjusted by this frequency to maintain alignment of the tuning elements. The filter1 and filter2 slope can be obtained from the '.map' file. As discussed before, ensure that you use two setpoints that are continuous. The filter1 and filter2 slope can be calculated by dividing the temperature difference by the frequency difference (typically 50GHz). The value should be around -0.11 C/GHz. For the 3.65GHz offset in the example, the filter1 and filter2 setpoints should be adjusted by (assume -0.1065 and -0.1080 for filter1 and filter2 slope) 0.389C and 0.394C, respectively. The temperature change of sled, filter1 and filter2 should all go in the same direction.